DEPARTMENT OF AGRICULTURE, PUNJAB.

HINTS ON SILKWORM-REARING IN THE PUNJAB

By

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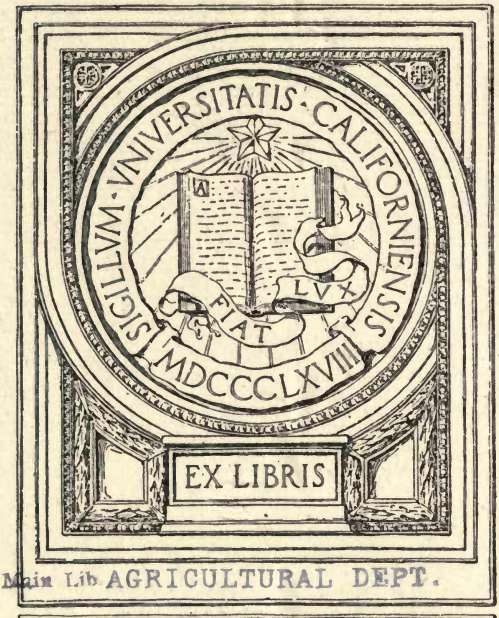
Lahore:

Printed by the Superintendent, Government Printing, Punjab.

1917.

Price : Re. 0-6-0 or 6d.



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INTRODUCTION.

It is hoped that this bulletin will be useful to any interested in sericulture in the Punjab. What is said herein is only recommended for the submontane tracts of this province, in which parts alone of it experience has shown that sericulture is practicable.

The portion of the bulletin that deals with the mulberry has been written by Mr. Mustoe, Superintendent of the Lawrence Gardens, Lahore.

C. A. H. TOWNSEND,

May 1917.

Director of Agriculture and Industries, Punjab.

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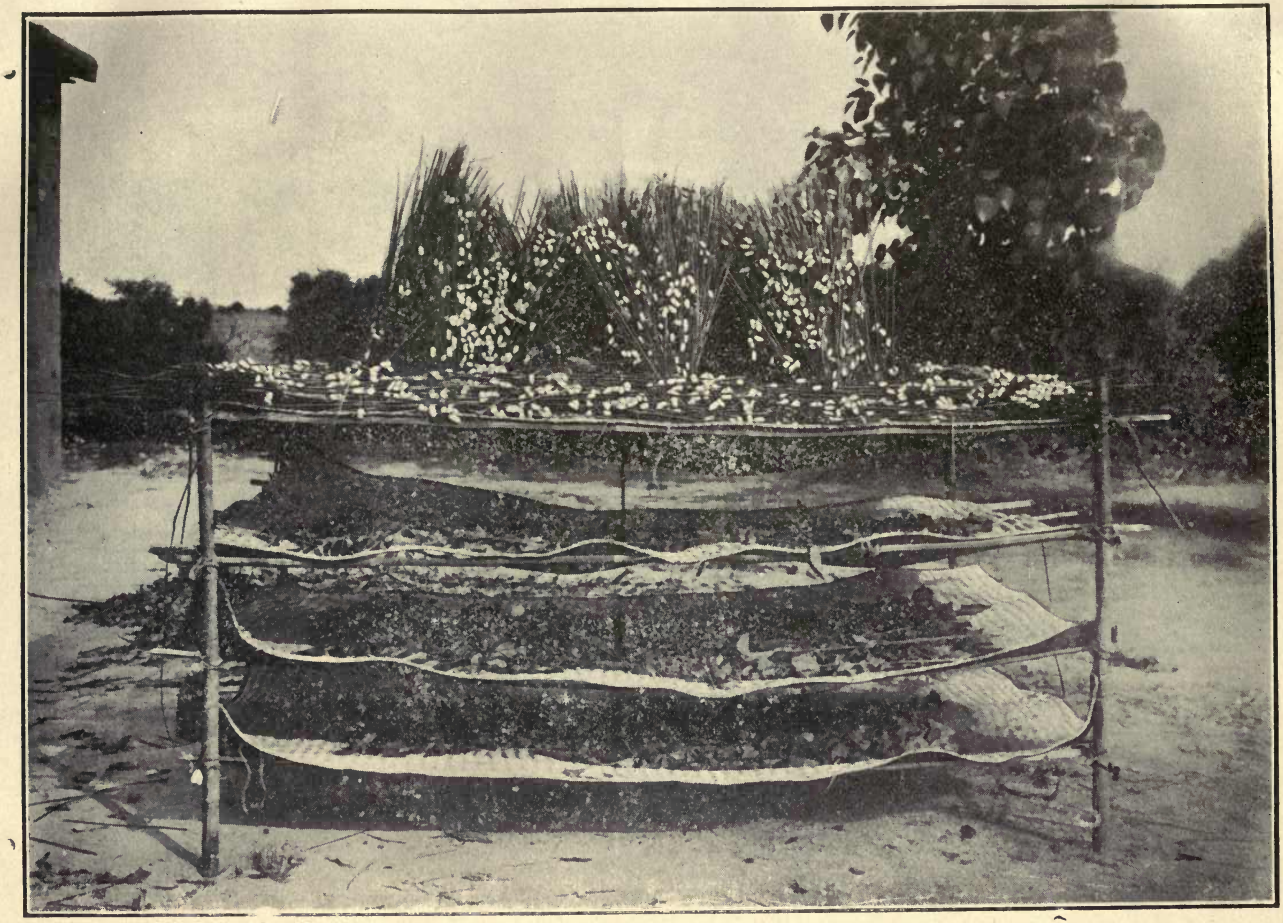

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PLATE II.

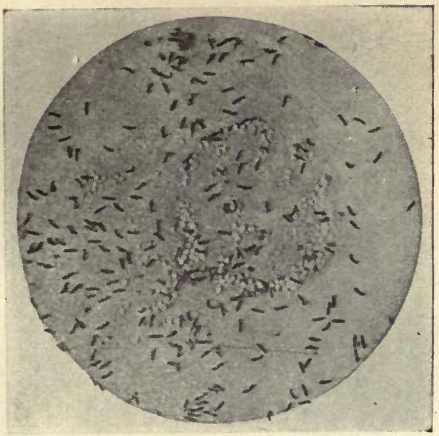

Fig. 1.—Newly hatched silkworms.

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Fig. 2.—Silkworms after third moult.

Fig. 1.—Silkworms before third moult.

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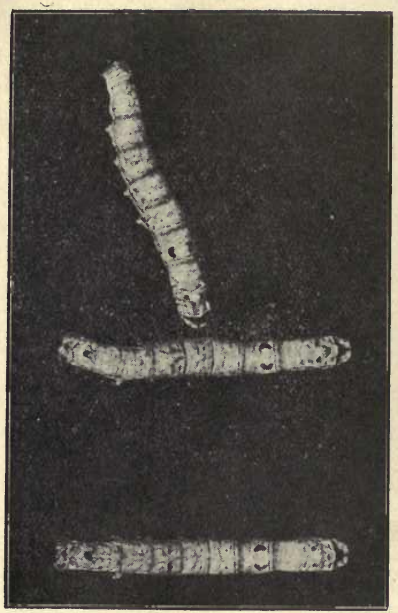

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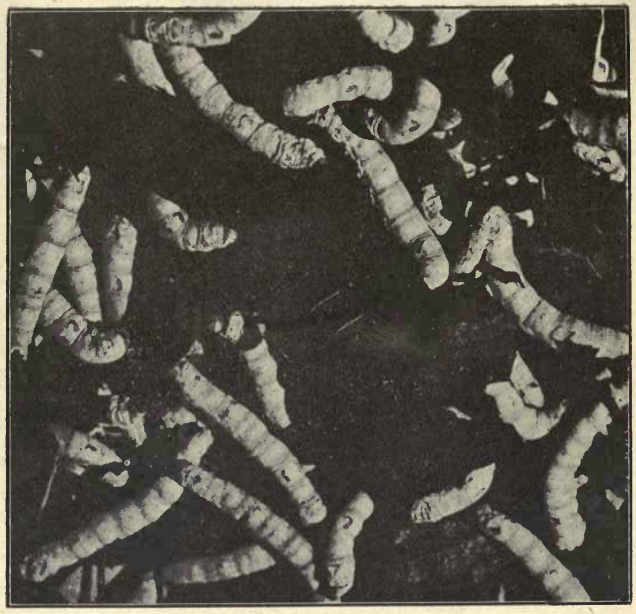

Fig. 1.—Silkworms full grown.

HINTS ON SILKWORM-REARING IN THE PUNJAB.

PART I.—THE CULTIVATION AND CARE OF MULBERRY TREES.

Varieties suitable for sericulture.

1. So far as is known, all the local varieties of mulberry are suitable for feeding silkworms in the Punjab. Plants of the common black or white small-fruited country varieties, with large leaves, not serrated at the edges or deeply lobed, are best. The Phillipine mulberry (*morus multicaulis*) is useful for producing leaf early in the season. It bursts into leaf one or two weeks before the ordinary varieties, and it thus allows of worms being hatched out earlier than usual. The same object can be attained by cultivating the local mulberry as a bush. The leaves of the Phillipine mulberry or bush mulberry are only suitable for young silkworms up to the second moult.

Methods of propagation

2. The mulberry can be propagated from either seed or cuttings, but as seedlings, when small, are very liable to be destroyed by excessive drought, sun or moisture, it is not advisable to follow this method of propagation. Propagation by cuttings is the simplest method; these should be made from strong shoots of the current year's growth removed from the parent tree as soon as the leaves have fallen in the autumn. The sets should be cut in lengths of one foot, all those smaller than an ordinary lead pencil being discarded, and only strong well-ripened lengths being retained for planting. In making cuttings, great care must be taken to see that both ends are cut as near to a bud as possible without injuring it. This remark specially refers to the lower end which is put into the ground. As the cuttings are made, they should be laid one way (namely, all the buds facing in one direction) and tied up in bundles of 100 each, and as each bundle is completed, it should be buried under a few inches of moist earth in a shady place: this will keep them fresh until they can be planted, and by laying the cuttings one way in the bundle, the planter has not to examine each one before planting to see that he has it the right end up.

Planting of cuttings.

3. When the required quantity of cuttings have been made, the planting should be done with as little delay as possible early in December.

Time of planting.

4. In India all hard wood cuttings are best planted before the end of December, to give them time to "callus" and make root before the sun gets hot enough to force them into leaf.

Soil and method of planting.

5. The best soil for planting is that containing a little natural moisture, and if possible with a little shade, but the latter is not of great importance if the planting is done early in December and the beds kept thoroughly moist by irrigation. The size of the beds will depend upon the amount of water obtainable; the soil should be dug up to a depth of one foot, well pulverised, and the surface made quite level; the cuttings should be planted perpendicularly about 9 inches deep, leaving 3 inches with 2 or 3 healthy buds above the surface. It is important when planting to see that a hole at least 10 inches deep is made for each cutting, as it often occurs that the operator makes a hole, say, 6 inches deep, and drives in the remaining three inches of the set with the *khurpi* or whatever tool is being used; this is bad, as it bruises the end of the cutting and, instead of roots, decay will be the result. Care should also be taken to see that the base of the cutting is made quite firm in the soil, and a good soaking of water given to each bed as it is planted: afterwards watering once in ten days or so will be sufficient. The best distance for planting is 6 inches apart in each row, with a distance of 8 inches between the rows: this provides plenty of room for a man to work between the plants for removing weeds, etc.

If there is any difficulty in obtaining suitable wood for cuttings, the best method is to prune back a few old trees very hard, that is to cut off all the small branches of less than 6 inches in circumference any time during December and January. This will result in the production of strong straight growths the following year similar to those from which mulberry baskets are made.

If the soil is fairly good, and these instructions are carefully followed, 80 per cent. of the cuttings will produce plants from 4 feet to 7 feet high by the following November.

Instrument for making cuttings.

6. The best instrument for making cuttings is a sharp knife, but when large numbers are required, cutting with a knife is too slow a process and scissors or secateurs are used: the best make being the "parrot's beak" pattern. These have two cutting edges, and if they are discarded as soon as they become blunt, bruising will be reduced to a minimum. They cost about Rs. 2-8-0 per pair, and, if carefully used, will make from 10,000 to 20,000 cutting before blunting, and can afterwards be used for rough work where clean cuts are not so important.

Tree plantations.

7. Mulberry trees should usually be planted along roadsides or around fields and gardens. The distance between these should be about 30 feet.

Bush plantations.

8. Bush plantations give a supply of tender young leaves earlier than large trees, and, as it is most important to have tender leaves available as early as possible in the Punjab, every silk-rearer should have a small bush plantation. To make a bush plantation young plants may be planted about two feet apart in a single line, or in lines four to five feet apart. After planting, the plants are cut down to the level of the ground. Hoeing, etc., should be done when necessary. In the spring following that in which the leaves for the young worms have been gathered the plants are cut down to about one foot from the level of the ground. This is repeated yearly until the plants become worn out. New plantations should be started two years before they are actually required. One hundred bushes will supply the worms from one ounce of eggs with food at least up to the second moult.

Pruning of young trees.

9. A sharp knife should, if possible, be used in all prunings. Scissors are apt to bruise the wood and leave a ragged end, liable to be infected by disease germs. All wounds should be cut clean, and large wounds should be coated with tar. The aim in pruning is to remove all diseased or dead wood as well as branches likely to interfere with the development of others, and to shape the tree so that it may produce the maximum amount of good wholesome leaves. In the case of a young tree, a suitable number of main branches should be selected which, if developed, would form a symmetrical tree. All others should then be cut away close down to the main stem, and the leaves from them

fed to the worms. Next, from each of the selected main branches all the buds should be stripped off except two facing outwards from the centre of the tree. These two buds should be near each other and at a height of 1½ to 2 feet above the place where the branch joins the main stem. Each of the main branches should then be pruned down to about half an inch from the top of the highest bud left, taking care not to harm the bud in doing so. This treatment should be repeated for a few years until the tree has attained a considerable size and its shape has become permanently fixed. But the tree should be visited every year before buds begin to sprout, and all dead twigs or badly shaped branches removed. Branches near the base of the main stem must not be cut off too soon from young plants. A few of these left on a plant help to strengthen the stem: but they should not be numerous nor be allowed to become thick. If under the above system of pruning the branches are getting too long and slender, two buds should be left a little nearer the base of the branches, the part of the branch above these being removed as before. Should the system of branches on the tree be too open, two buds facing inwards may be left instead of two facing outwards.

Pruning of old trees.

10. To rejuvenate old trees, the earth around their roots should be loosened and they should be manured well in the autumn. In the spring, the main branches should be cut off, 3 to 4 feet from the trunk. The following spring when the leaves are being gathered, all buds, except two about two feet high on the outside of each reserved young branch, should be removed: these branches should be cut about a half an inch above the highest bud. Older branches should be removed completely. This treatment should be continued until the tree has reformed its top.

Removal of leaves from tall trees.

11. To remove leaves from tall trees, an instrument such as that employed by goat-herds for removing leaves from trees may be used. But if it used, it must be very sharp, and the branch will be cleanest cut if it be struck at an angle of about 30° and the blade meets it in a perpendicular plane from the side nearest the centre of the tree. Special long handled shears which can now be obtained for cutting twigs from all trees, would serve the purpose

well, if properly sharp. Twisting and bruising of branches must be carefully avoided, as, besides damaging the tree directly, these readily admit disease germs which may produce disastrous results. In cutting down leaves from a big tree, small twigs should be cut. People are apt, however, to cut down large branches so as to get a large quantity of leaves without much trouble : a practice highly injurious to the tree. No person should be allowed to take branches over half an inch in diameter from trees without permission. Care should also be taken that less than three-fourths of the leaves are removed from any one tree in any year, and that these leaves are removed equally from all round the tree.

PART II.—THE REARING OF SILKWORMS.

European silkworms.

12. Though there are various kinds of mulberry feeding silkworms, *bombax mori*, the European silkworm, is the best, and it alone should be reared in the Punjab to the exclusion of all other varieties. This silkworm produces only one crop a year, in the spring. Its cocoons are superior and contain more silk than any other variety of mulberry cocoons.

Tracts suitable for rearing.

13. European silkworms require a temperate climate for their rearing and an equable temperature and a tolerably moist atmosphere to spin good silk. In the Southern and Central Punjab these conditions do not generally obtain, as the spring, which is the time for silk spinning, generally becomes hot early. But in the Northern Punjab, especially in the submontane tract, these silkworms do well.

Supply of disease-free eggs.

14. Eggs should on no account be prepared locally, for they are liable to be disease-infected. Guaranteed disease-free eggs should be obtained every year from the best European grainage establishments through the Director of Agriculture and Industries, Punjab : to him notice of requirements for the following spring should be given by May 15th. These eggs cost Rs. 2-8 per ounce, plus freight charges, which come to about two annas an ounce. The eggs arrive in India from Europe early in October : during the cold weather they are kept for hibernation at Simla, at

a temperature below 45° F.: a higher temperature during this period will prove injurious. In the first week of February, in time to commence the hatchings, the eggs are brought down to the plains and distributed to the rearers.

Quantity of seed per household

15. Sericulture can be developed only as a cottage industry: large rearings have always been shown to be unprofitable. Small families of three persons can rear only one ounce of seed (30,000 eggs). Bigger families may try two ounces but that should be the maximum in all cases: for beginners half an ounce per family is quite sufficient. A very general mistake is to take too much seed. To rear an ounce of silkworm seed 25 full-grown mulberry trees are necessary, a point which should be carefully borne in mind.

Incubation of seed.

16. The incubation of seed is effected as follows :—

(1) Date of starting incubation.—

The incubation of the seed should be started as early as possible in February so that the cocoon crop should be finished before the setting in of the greater heat about the middle of April. The incubation period is two weeks, and the life of the worm to spinning time is 45 days.

Eggs should be put out to hatch after, if possible, being dipped in 1 to 2 % copper sulphate solution and then dried in the shade,—see paragraph 27 (2) and (3)—as soon as buds begin to sprout on mulberries, so that the hatching out of the worms may coincide with the opening of the young leaves. The *Desi Katha* mulberry trees produce buds about the 15th of February which come in leaf at the end of that month. Hence where early-leafing mulberries are not available incubation cannot be started before the middle of February. Where, however, even a small amount of Phillipine mulberry is available, incubation can be started earlier, as they produce leaves about twelve days before the *desi* mulberry.

(2) Method of incubation.

Incubation is effected by keeping the seed at a uniform temperature of about 77° F. till all the worms hatch out. Any sudden variations in temperature during this period are extremely injurious and should be avoided.

Various methods of incubation are in practice. Some of them are most primitive. Of these the commonest are—

(*a*) Keeping the seed in small bags suspended next to the body.

(*b*) Keeping the seed in the heat of the sun in the day time and inside the bed quilt at night. Hatchings by these methods are, it need hardly be said, not successful: they go on for a long time; the worms are poor and unequal, and the crop is often entirely bad.

Incubation should be done either by the fire or by the incubator :—

Incubation by fire.—This is affected as follows :—

A small room in the house is selected which is as little exposed as possible to the sun. The eggs are taken out of the box and placed in a heap on a sheet of white paper on a small stool (*piri*) in the room. The legs of the stool are set in plates containing water to prevent ants ascending : and the eggs are covered over with a small open work basket to keep rats off. A basin containing water is also placed near the eggs to create a moist atmosphere : this is essential to successful hatchings. A small thermometer is also placed in the room to indicate the temperature.

As soon as the eggs have been thus exposed fires are lighted in the room to keep it uniformly warm day and night.

A dung cake fire is the best and cheapest. The cakes are lighted outside the room in the open, and are brought in only when they have become perfectly smokeless. Fires are kept up regularly till all the hatchings are over. Special care should be taken to keep the fire well alight through the night: it should be built up with cinders, as it will thus give heat more evenly and for a longer time.

The room should be kept at about 77° F. It is difficult to keep a very even temperature by the method just described; small variations, however, do not make much difference : hence if the temperature is kept between 70° F.—80° F. day and night, the hatchings will be quite satisfactory. Any rise of temperature above 80° F. should be especially avoided as it makes the worms weak and liable to disease.

Thermometers are useful but are beyond the reach of ordinary village rearers. A pleasant heat should be aimed at. Practice is the best guide in this matter.

Incubation by incubator.—This is the best system to obtain regular and early hatchings. Two incubators have been found useful and can be recommended. One is the French castelet in which large quantities of seed (20 ozs.—32 ozs.) are hatched at a time. This can be used only where the rearers combine to make up the necessary amount of seed.

Another incubator, called the "Home-Incubator," has been devised by the author for the cottage rearer in which one to two ounces of eggs can be successfully hatched. It is cheap and simple in its working, and can be used by even the most ignorant villager.

The seed is placed inside the incubators in which are special arrangements for heating and regulating the temperature. During the incubation period the temperature should be kept constant day and night as follows :—

For the first four days	...	65°F.
For the next four days	...	70°F.

then till the hatchings are over 77° F. Persons wishing to buy either of these incubators should apply to the Director of Agriculture and Industries, Punjab.

(3) Turning of eggs during incubation.

During incubation the eggs should be turned over three or four times each day with a feather. This will render the hatchings uniform. Care should be taken never to touch the eggs with the fingers.

Preparation of rearing rooms.

17. Rearing rooms should be prepared in the following manner :—

(1) Rearing room.

After the eggs have been laid out for hatching preparations should be made for the reception of the worms They are reared in-doors, and throughout their existence must be protected from sun, wind and rain. No specially elaborate erections or houses are required for them : the ordinary mud walled dwelling rooms or cattle sheds are suitable for all domestic rearings. Part of the rearing room can be used by the family for sleeping or other household purposes as well. The room selected for housing the worms should have ample means of ventilation. There should be a door facing north or south and one or two windows or ventilators, which should be kept open.

(2) Construction of racks.

In order to rear a maximum number of worms within a limited cubic space it is necessary to construct racks (plate I, fig. 1) at one end of the room. To accommodate the worms produced by one ounce of seed two racks of the following dimensions should be constructed. Make a frame work 8′ × 4′ by placing upright on the floor four thick pieces of wood or bamboo, 8 feet high, and make five rows on it by tying cross-bars of thick branches or bamboos. The first row should be two feet above the ground and the distance between the other rows should be 1½ feet. Pieces of matting 8′ × 4′ should be spread on each row and the worms should be reared on these.

Rearing the worms on the floor is most insanitary for it results in :—

(*i*) overcrowding of the worms ;
(*ii*) inadequate ventilation ;
(*iii*) loss of crop by rats, ants and lizzards.

The construction of racks should be always insisted upon.

(3) Disinfection.

The rearing-room should be disinfected before commencing operations by leeping the floor and walls with cow dung. Further one *chatak* of copper sulphate should be dissolved in a kerosine tinful of water, and this solution should be thoroughly sprinkled on the floor and walls before the worms are brought in. If the room has not been in use for domestic purposes it should also be fumigated with sulphur. For this the windows and all other apertures should be closed and four ounces of powdered sulphur should be put in an earthen vessel on a stove (*angithî*) containing burning charcoal. The sulphur will gradually melt and burn. The doors, windows and other apertures should be then immediately closed. The room should remain closed for 24 hours : in that time the sulphur fumes will destroy all germs. All doors and windows should then be opened and the room thoroughly ventilated for a day.

(4) Protection against enemies.

In villages *kacha* houses are generally infested with rats, ants and lizzards which do great damage to silkworms. Sparrows also do considerable damage.

The following measures should be taken against these enemies during the rearing season :—

Rats.

(*i*) All rat holes in the room should be closed and vessels containing flour mixed with a little arsenic should be placed on the floor.

(*ii*) Four cones of tin should be nailed one on each leg of the rack about 9 inches from the ground with the concave side downwards. These will prevent rats climbing up.

(*iii*) To prevent damage from rats and lizzards which drop from the ceiling an extra tier should be made on the top of the rack and some thorny branches should be spread on it. This will prevent these animals from descending to the lower tiers.

Ants.

(*iv*) A paste made by boiling a quarter of a seer of resin (*ganda baroza*) in half a seer of *toria* oil, to which some *âk* (calatropis) juice has been added, should be smeared round the legs of the racks to keep off ants. The paste should be kept fresh on the posts and not allowed to dry.

Sparrows.

(*v*) Cheap bamboo or reed chicks should be hung in the front of doors and windows to keep out birds and flies.

The hatching of the eggs.

18. On about the twelfth day after incubation starts the eggs begin to show signs of hatching ; they change colour

and swell. Hatching actually begins on about the fifteenth day, and, if the incubation has been properly done, all the eggs hatch out in four or five days.

The lifting of silkworms.

When the hatching commences, for the first one or two days only a few worms emerge. They should not be separated but should be left where they are till a fair amount of worms have appeared. Then a fairly large piece of mosquito curtain net (*jali*) should be spread over the eggs, and on it should be placed a good many young tender mulberry leaves. The young worms attracted by the scent of the leaves pass through the meshes of the *jali* and cluster on the buds. The *jali* is essential, for otherwise the empty shells and unhatched eggs will also be dragged along with the hatched worms entangled in the food. In about two hours all the hatched worms pass through the *jali* and collect on the leaves. Then these leaves laden with the worms should be carefully taken up and placed on a sheet of paper on the lowest shelf of the rack.

Hatched out worms should thus be separated from eggs once a day. Hatching out mostly takes place in the morning up to ten o'clock : so to keep the worms of the same age together, mulberry leaves should be placed on the *jali* after ten o'clock each day when the day's hatchings have been finished. It is true that worms hatch out later on in the day also, especially in the evening, but this number is so small that it is not worthwhile to separate them the same day : they can easily wait without food till the next morning.

The worms in each batch are of the same age and size, and, in order to keep the rearing regular, it is essential not to mix together the different batches : each should be kept and reared separately throughout.

Life of silkworm.

19. In properly conducted rearings the life of the silkworm from hatching to maturity is about five weeks. It is divided into five stages : after each stage the worms undergo a moult and the old skin, which becomes hard and incapable of keeping pace with the internal growth

of the worm, is cast off. A new tender skin is developed, and the worms grow considerably in size :—

First stage.—On emergence from the eggs the worms are small, black and hairy (plate II, fig. 2). On the third day the worms appear stronger and with less hair. This stage lasts for five days, then the worms moult : this takes a day (plate II, fig. 1).

Second stage.—(Plate II, fig. 3)—The worms lose the hair on the body and become greyish in colour. They become bigger in size. They remain in this stage for about 5 days and then begin to moult again (plate II, fig. 4).

Third stage.—(Plate II, fig. 5.)—The worms become quite smooth and hairless ; generally they are white but some may be black or have black stripes. This stage lasts for about a week, and during this period the worms grow considerably : then they moult again (plate III, fig. 1.).

Fourth stage.—(Plate III, fig. 2.).—This is a critical stage in the development of the worms. Diseases due to bad seed or want of hygienic care of the worms appear during this period. It lasts for about six days and then the worms moult for the last time.

Fifth stage.—This is the last stage prior to the spinning of cocoons ; the worms become large with fat bodies (plate IV, fig. 1).

They feed for eight or nine days, when they become translucent yellow in colour and are ready for spinning (plate IV, fig. 2).

Signs of moulting are a cessation from feeding, the enlargement of the head and the elevation of the forward third part of the body. The skin becomes shiny and threads of silk appear on the litter, by means of which the body become attached to leaves. The worms lose their vivacity, the head assumes an upright position, and the worm goes to sleep. They generally remain in this condition for about twenty-four hours. Nothing should be done to disturb them during this period. Signs of Moulting.

20. Full directions have already been given as to the management of the eggs. Similar instructions are now given The management of the worms.

as to the management required for the worms. In order to carry out rearings successfully, the following points should be carefully observed in their management :—

(1) Proper temperature and ventilation.

(2) Spacing of the worms.

(3) Regular feeding with proper leaves.

(4) Cleanliness—Removal of litter and refuse leaves.

(I) Temperature and Ventilation.

Temperature.—The optimum temperature for silkworms is 75° F., but it is practically impossible for the rearer to attain this day and night. Generally speaking the limit of 70° F.—80° F. should not be exceeded. In our submontane climate smouldering dung cake fires in the rearing rooms are essential till about the 10th of March. Later on till about the 25th of that month small fires are needed only during the night, but generally not after that date. As to temperature, an easy rule to be borne in mind is that the temperature which is most agreeable to man is also the temperature best suited to the rearing of silkworms. Hence the rearing rooms should be kept agreeably warm day and night.

Ventilation.—Sufficient ventilation is necessary throughout the rearings, especially after the fourth moult, when an enormous quantity of water vapour is given off by the worms and the mulberry leaves.

During this period all the doors and windows should be kept open to allow a free passage of air. Generally it is also necessary to keep little heaps of quicklime in the room to absorb the moisture, especially when the weather is rainy. Damp air is extremely dangerous as it induces the diseases of muscardine and flacherie amongst the worms.

Heat waves.—In the Central and Southern Punjab worms are liable to damage by heat waves early in April. The following means should be adopted to bring down the temperature :—

(*i*) Water the roof of the house just above the racks.

(*ii*) Hang large damp sheets over the worms.

(*iii*) Strong draughts of air should be kept passing through the room by opening all possible means of ventilation.

(2) Spacing of the worms.

Space is an important factor in determining the outturn, and a sufficient amount of it should be given to the worms throughout. Rearers do not generally realise the importance of this : they grow large quantities of worms which are allowed to remain crowded together. The result of this is that the worms remain small and feeble and produce a poor crop of inferior silk and not infrequently fall victims to disease.

Worms which have ample room for development become strong and healthy and spin large well covered cocoons. The space required for the worms produced by one ounce of seed is as follows :—

First stage.—Twenty square feet; the worms should not be allowed to come in contact with each other.

Second stage.—Forty square feet.

Third stage.—Eighty square feet.

Fourth stage.—One hundred and sixty square feet.

Growth is very rapid and so plenty of space should be given.

Fifth stage.—Three hundred to five hundred square feet.

Provision for ample space is most important during this stage as the success of the crop depends mainly on it. The rule is that the more space is allowed the more silk will be produced.

(3) Feeding the worms.

Mulberry silkworms can be fed only on mulberry leaves.

(*i*) *Quality of leaves required.*

A safe rule is "age of leaf to age of silkworm." Young worms should be fed upon young and tender leaves and the mature worms should be given mature leaves.

From hatching to first moult.—The tenderest young green leaves from the tips of mulberry shoots which have nearly opened and are still of a very pale green should be given : those which have not yet unfolded should be avoided. The amount of food required at this stage is small, and should be gathered fresh for each meal.

From first to second moult.—Young tender leaves should be served. If, however, very tender leaves are not available and more developed ones have to be given, they should be chopped into small pieces before serving.

Note.—Leaves from bush mulberries or from early leafing varieties, if available, should be used only up to the second moult. After that the worms require to be fed on leaves gathered from *Katha* black or white fruited mulberry trees.

From second moult to third moult.—Fairly mature leaves from mulberry trees should be collected and given whole.

From third moult to seriposition, or the spinning of the cocoon.—Fully mature leaves should be served whole and a few leaf-bearing twigs should be given at the same time. The twigs take the weight of the leaves off the worms, facilitate ventilation, and the worms become stronger by walking on them. The proportion of the twigs should be increased as the worms grow bigger, and in the fifth stage about quarter inch thick branches covered with leaves should alone be given.

Avoid dusty, wet and fermented and dried up leaves. They are unwholesome and cause disease. Dusty and wet leaves should be cleaned by wiping with a piece of cloth. Fermented and dried up leaves should not be used at all.

(*ii*) *Quantity of food.*

The quantity of food required gradually increases with the age of the worms. The following table gives roughly the daily consumption of leaf during each stage for the worms produced by one ounce of seed.

	Seers.
In first stage	5
In second stage	15
In third stage	45
In fourth stage	135
In fifth stage	about 25 maunds.

Up to the third stage the food required is small in quantity, but during the last two stages the appetites of the worms are astounding and they feed most voraciously.

The fault with the average rearer is that he gives too much food to the young worms and thus retards their growth ; and he underfeeds the worms in the last stages, which therefore remain small and weak and produce little silk. It is most important to feed the worms sufficiently during the last stages.

(*iii*) *Time of collecting leaves and feeding the worms.*

Leaves should be gathered twice a day, once in the morning about 10 o'clock when the dew has disappeared, and once in the evening before sunset. The leaves gathered in the morning should be sufficient for the midday and the evening meals, and those gathered in the evening should be sufficient for the night and the morning meals. To avoid fermentation or drying up the leaves during the daytime should be kept in a cool shady place and stirred three or four times, and at night they should be placed in the open and covered with a piece of cloth to keep

the dew out. Till the last moult, worms should be given four feeds a day. Convenient times of feeding are —

7 A.M., 12 A.M., 5 P.M. and 10 P.M.

If up to the second moult an extra meal can be added between 12 and 5, say at 3 P.M., so much the better.

In the last stage more than three meals should not be given in any case ; the best times for these are :—

7 A.M., 2 P.M. and 10 P.M

The last meal should be larger than the others.

(iv) Proper feeding during moulting.

Each time when the worms are about to moult their meals should be small and frequent of tender or chopped leaves. No food should be given to moulting worms : it is injurious as it disturbs them. But feeding should not be stopped till all the worms have gone to sleep. Those which are not asleep require food before sleeping, so small quantities should be sprinkled on them from time to time till they have all gone to sleep.

When all the worms have begun to moult feeding should not be resumed for about twenty-four hours till all are well out of the moult; for if some are fed early and some late, the equality of age will be disturbed.

(4) REMOVAL OF LITTER.

Litter is the refuse leaf and excreta of the worms. It should not be left lying on the racks but should be periodically cleaned away. The simplest way of doing so is to serve a meal of tender end branches of leaves or of whole leaves to the worms. When the worms climb on them they should be lifted and placed on a clean place. Precautions should be taken that no healthy worms are thrown in the litter which should therefore be carefully examined and any worms in it should be removed. If, however, a few sickly looking worms are found they should not be separated. The refuse litter should be taken in a basket to some distance from the house where it should be stored in a pit, and used for manure. On no condition should it be allowed to lie about in the room, as it causes infectious diseases amongst the worms.

Litter should be removed as follows :—

First removal	...	... Two days after the first moult.
Second ,,	...	... Two days after the second moult.
Third ,,		... After the third moult.
Fourth ,,		... After the fourth moult.
Fifth ,,		... On the sixth day in the fifth stage.

It is extremely important to keep the rearing house as clean as possible. Sweeping or cleaning should be done gently and dust should not be raised.

Spinning of cocoons.

21. The worms when fully mature begin to spin cocoons.

(1) Signs of maturity.

On the fifth or sixth day after the fourth moult the worms approach maturity : their appetites diminish and their bodies become translucent. Two or three days afterwards they become fully mature : they cease to eat, protrude their heads as if looking for something, their bodies become completely translucent, and from the mouth exude threads of silk. They begin to wander, begin to crawl away from the trays and to climb up the sides of the racks. This instinct to mount shows that they are about to spin. They must then be provided with a spinning place.

(2) The heath or spinning material.

Worms should not be allowed to spin their cocoons in the litter, but suitable material should be provided on which they can climb and spin. Clean and dry twigs called the " heath " are the best ; branches also of trees or bushes, or stems of rice, wheat, toria or sarson, or some other non-resinous crop is used for this purpose : it should be used as follows :—

On the fifth day after the fourth moult some bundles of these twigs or stems are tied at regular intervals on the posts and cross pieces of the racks. The early mature vagabond worms will come in contact with these bunches and spin their cocoons in them.

When the worms begin to mount the bundles, these are placed in an upright position in the litter amongst the worms (plate I, fig. 1). Care should be taken to provide plenty of them so that all the worms have twigs to mount within easy reach. These bundles are arranged in such a way that their tops come in contact but sufficient space is left in between at the bottom to remove the litter, and to feed the worms which are not quite ripe.

(3) Spinning.

The mature worms mount on the heath and begin to spin cocoons. During this period they are most susceptible to accidents and great care should be taken of them. Some of them fall from the heath : they should be replaced on it : others are in awkward positions : they should be removed to better positions.

When worms cannot easily find the heath they cast their silk on the litter. Such worms are called " short worms." They should be picked up and placed in a comfortable position on the heath.

On the fourth day after the worms have begun to climb, all the backward worms, which are not yet mature, should be separated, and light food and heath should be supplied to them. All the litter should be removed from the old bed. This is necessary as the ripe

worms in mounting the heath emit a large mass of semi-liquid excreta which produces dampness and is extremely injurious to worms which are not yet mature.

During the period of spinning the temperature should be above 65° F. and below 80° F. A temperature of about 75° F. is the best. The rooms must be thoroughly ventilated, and all the doors and windows should be kept open.

Collecting cocoons.

22. About ten days after the worms have mounted, the heath is gathered and the cocoons are picked off the branches and the bits of twigs and leaves adhering to them are brushed away.

Good cocoons.

23. Good cocoons are regular in size, colour and shape. They resist pressure from the fingers.

Faulty cocoons.

24. Faulty cocoons are those of abnormal size, shape or colour, or which do not resist the pressure of the fingers. These should be put in a separate basket. Among them may be found :—

(1) Double cocoons.

These are unusually large and are formed by two silk worms having seriposited together. This happens frequently, if worms are over-crowded while seripositing. These cocoons will not reel properly.

(2) Velvety or satiny cocoons.

These are soft and velvety to the touch, and this is said to be either due to abnormal feeding or temperature during rearing or to inherent defects in the eggs. These cocoons give poor and broken threads when reeled.

(3) Saffron cocoons.

These are saffron coloured : this is said to be due to inferior eggs. These cocoons give little silk and that of a bad colour.

(4) Stained cocoons.

These cocoons show a black mark at one end, due to a dark liquid emitted by a dead and decomposing chrysalis inside. No noise will be heard if the cocoon is shaken close to the ear. Melted cocoons may be the result of want of air in the nursery after rising or of disease in the worms. The silk is poor.

(5) Imperfect cocoons.

These usually have a thin end and are almost transparent showing the inside. This defect is ascribed to low temperature when the worms are seripositing.

(6) Weak cocoons.

These cocoons are easily pressed in and out by the fingers, making a dry cracking sound meanwhile, or are easily pressed and will not resume their original shape. This defect is caused by worms having lost part of their silk secretion before having started spinning. They may have fallen off the heath or have been disturbed, or they may have been unable to find a suitable twig till after they had started seripositing. These cocoons will naturally be smaller on account of the silk lost. Weak cocoons are also caused by the death of the worm while seripositing. Muscardine may bring this about, but in this case the chrysalis inside will be dead and dried up and the colour of the cocoon will be clearer and redder.

Killing the cocoons.

25. Insects which are inside the cocoons emerge about ten days after they have been gathered, so in order to preserve the cocoons it is essential to kill the inside worms before they make their way out. This is generally done by exposing the cocoons to the heat of the sun for two or three days. Cocoons are spread out on matting in the sun, and are covered over by a black cloth to keep the light off them, as the sun's rays falling directly on the cocoons ruin the silk and the colour of the cocoons. When the insects have been killed, which is ascertained by cutting open a couple of cocoons, the cocoons are gathered and put away safely in bags till they can be disposed of.

Produce and sale of cocoons.

26. If the rearing has been successful a crop of 38 to 48 seers of green cocoons per ounce of seed should be obtained. When these cocoons are stored for about a month they become dry, and loose quite two-thirds of their weights ; so the dry crop is equal to 13 to 16 seers. This is sold according to the quality of the cocoons and the price for dry cocoons generally varies between Rs. 80 and Rs 120 per maund. So a careful rearer can on average earn from Rs. 25 to Rs. 48 from an ounce of seed.

An annual exhibition of silk cocoons is held by the Department of Agriculture, generally at Gurdaspur, at the end of May. Small prizes are distributed according to the quality and quantity of the exhibits, and arrangements are made for the sale of the silk cocoons.

Diseases of silkworms.

27. Silkworms are liable to certain infectious diseases, of which four are important. Every rearer ought to be able to recognise these diseases, to know the causes which produce them, and also the simple measures, the adoption of which in time will prevent the spreading of the infection from unhealthy to healthy worms. There is no known cure for any of these diseases, and affected worms can not be saved. Below are given these four important diseases :—

(1) Pebrine.

This disease is the most serious of all. It is hereditary. The eggs laid by pebrinized moths are infected; and the worms which hatch out from them all perish towards maturity.

The only preventive measure is to rear healthy seed, which has been laid by untainted moths. There is no fear of this disease, when healthy eggs laid by microscopically examined disease-free moths are used.

Worm born from healthy seed may also contract this disease during life, but this does not always prevent their spinning, as the disease reaches its climax and kills the worms 30 days after infection.

Black spots on the body are the outward characteristics of the disease; internal signs are oval corpuscles, only visible through the microscope.

(2) Flacherie.

This fatal disease manifests itself after the worms have passed their fourth moult when they are mature and even while spinning. All of a sudden without any apparent cause the victims begin to languish : then become completely still and soon die. They turn black after death and become putrid. The principal causes of the disease are—(*i*) eggs becoming spoiled through careless preservation ; (*ii*) hereditary tendencies ; (*iii*) feeding on wet, dewy, dusty or fermented leaves ; (*iv*) sudden change of diet from tender leaf to tough leaf ; (*v*) lack of ventilation ; (*vi*) excessive heat, *i.e.*, above 80° F. ; (*vii*) worms having been kept too thick ; (*viii*) putrifying worms forming a medium for micro-organisms and infesting the others. If these causes are avoided flacherie is not likely to invade a rearing.

To prevent contagion (*i*) silk worm eggs should be dipped in a solution of copper sulphate before being incubated ; (*ii*) sick and dead worms should be regularly picked out and buried deep in the ground at a distance from the rearing house ; (*iii*) in cleaning the matting powdered lime or copper sulphate should be applied where a dead worm is seen.

(3) Muscardine.

This is the most contagious of all silk worm diseases and is caused by the growth of a mould fungus in the body of the insect. The chief cause of the disease is neglect to change the beds and the keeping of litter in and around the room.

As a rule it makes its appearance after the fourth moult. The affected worms become languid, turn red and soon die. After death the body dries and is covered with white efflorescence which is full of the spores of the mould. This is the real sign of the disease.

Even if only one or two silk worms are found dead of this disease, the following precautions should be immediately taken ; any delay will result in the destruction of the whole rearing : -

(*i*) All the dead worms should be removed and burnt.

(*ii*) A one per cent. solution of copper sulphate should be sprinkled on the racks and trays ; care being taken that none touches the worms. The floor should also be leeped with the solution, which should be made fresh each time : old solution is of no use.

(*iii*) The rearing room should be fumigated with half a seer of sulphur for 5 or 6 hours till all the diseased worms are located. The fumes kill the spores of the disease but do no harm whatever to the healthy worms. It is remarkable that the quantity of sulphur fumes that would kill rats, lizzards or even human beings do no harm to silkworms.

After fumigation fresh food should be given to the worms.

One day's fumigation will not kill all the disease spores ; those which are inside the body will escape : so it is important to do the cleaning and burn one ounce of sulphur each day so long as the dead worms are found.

Method of sulphur fumigation.

People generally do not know how to burn sulphur. They put fire in a basin and sprinkle some sulphur on it ; the result is that the sulphur soon cakes, and extinguishes the fire and very little of it is converted into fumes. This sort of fumigation is of no use. The proper method is to powder the sulphur and put it on a tin sheet which should be placed on a slow fire. The sulphur will gradually melt and catch fire till the whole of it is converted into fumes.

(4) GRASSERIE.

Silkworm having this disease become restless, bloated and yellow. If punctured they exude a purulent matter which under the microscope swarms with minute polyhedral granular crystals.

This disease is neither contagious nor hereditary, nor is it caused by any living organism.

In the climate of the Punjab it generally does not become serious ; only a few worms are affected here and there, but in a few cases it has been seen to assume an epidemic form. The cause is generally mismanagement of the worms at the moulting periods, when feeding has been stopped before all the worms have gone to sleep, or has been recommenced before all the worms have come out of sleep.

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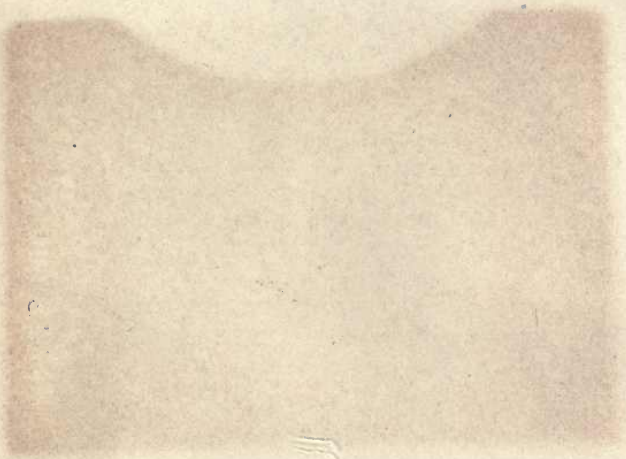

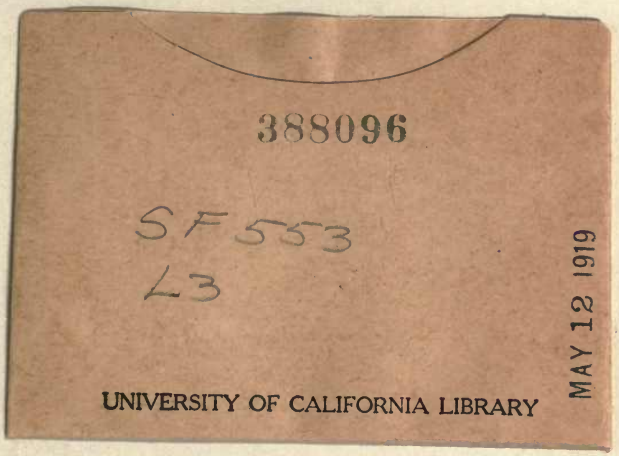
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